World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:19, No:04, 2025

The Study on Effects of Magnetic Annealing Atmosphere for Silicon-Modified Fe-Cr-C Alloy Steel

Authors : Che-Wei Lu, Fei-Yi Hung

Abstract : This study investigates silicon-modified Fe-Cr-C alloy steel, a soft electromagnetic material characterized by low coercive force and high magnetic permeability. This material maintains stable magnetic properties even under high-temperature or high-frequency environments, making it widely applicable in various electromagnetic components. Increasing the silicon content in the alloy enhances the base fluidity, thereby improving magnetic properties such as reducing hysteresis loss and increasing operational efficiency, which contributes to superior soft magnetic performance. Considering that electromagnetic materials may exhibit delay phenomena during operation, which reduces their efficiency, this study employs magnetic annealing processes with different atmospheres (air and hydrogen) to evaluate changes in the microstructure, mechanical properties, and magnetic characteristics of silicon-modified Fe-Cr-C alloy steel. The experimental results reveal that annealing treatment significantly affects the material’s microstructure, resulting in an equiaxed grain structure. XRD analysis of the matrix phase and material texture indicates an increase in the intensity of the α(110) crystal plane, which is associated with superior soft magnetic properties after annealing. This suggests that annealing promotes favorable crystal alignment, further enhancing magnetic performance. Additionally, tensile test results show that the material's mechanical properties, including tensile strength and ductility, are improved after annealing. Further analysis of magnetic properties demonstrates that magnetic annealing effectively mitigates delay phenomena, resulting in more stable and efficient electromagnetic responses. This is crucial for motors, transformers, and other electromagnetic device applications. In summary, this study highlights the importance of silicon- modified and annealing process control in improving the microstructure and properties of Fe-Cr-C alloy steel, offering a new research direction for advanced applications of electromagnetic materials. Furthermore, mitigating delay phenomena and enhancing operational efficiency underlines the significant advancements in the material's magnetic properties.

Keywords : Fe-Cr-C alloy steel, magnetic annealed process, mechanical property, hysteresis curve
Conference Title : ICMME 2025 : International Conference on Metallurgical and Materials Engineering
Conference Location : Tokyo, Japan
Conference Dates : April 17-18, 2025